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TITLE

METHOD AND APPARATUS FOR USING THE VOICE OVER INTERNET PROTOCOL TO HANDOFF CALL CONNECTIONS

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BACKGROUND OF THE INVENTION

Cross Reference to Related Applications

This application is related to U.S. Patent Application No. 09/464,124 filed December 16, 1999, "Method for Conducting Handoff Back Communication Scenarios"; and U.S. Patent Application No. 09/540,073, filed March 31, 2000, "Method for Conducting Handoff Back to Anchor Communication Scenarios" which are each incorporated herein by reference in their entirety.

Technical Field

This invention relates generally to mobile cellular telephone communications, and more particularly, to a method of utilizing existing signaling protocols, such as the American National Standards Institute (ANSI)-41 protocol, to implement more efficient communication operations, including handoff operations, using the Voice over Internet Protocol (VoIP).

History of Related Art

Unless telecommunication subscribers communicate through the same switch, voice and signaling trunks are typically required to support communications. These physical resources are appropriated within a network as required. For example, turning to Fig. 1, the typical prior art scenario illustrating two mobile telephone subscribers engaged in conversation, as once subscriber moves away from an anchor Mobile Switching Center (MSC) to a target MSC, is shown. In this figure, a voice call is established between mobile station **110** and mobile station **120** using the anchor MSC

160. During the course of the conversation, the mobile station **120** moves away from position **130**, through position **140**, to position **150**. As the mobile station **120** moves away from the position **130** to the position **150**, the mobile station **120** is assumed to move outside the coverage range available to the anchor MSC **160**, and within the coverage range of the target MSC **170**. The signaling trunks **180**, **185** are used to communicate signaling messages for information interchange between the network entities **160**, **170** and the Home Location Register (HLR) **175**. As the mobile station **120** moves away from the anchor MSC **160**, the anchor MSC **160** establishes communication with the target MSC **170** to request resources to continue the services offered to the mobile station **120**. Thus, as the mobile station **120** is handed off from the anchor MSC **160** to the target MSC **170**, various messages, such as HANDOFFMEASUREMENTREQUEST, FACILITIESDIRECTIVE, and MOBILESTATIONONCHANNEL messages (assuming we use ANSI-41 standard, for example) are sent and received using the signaling trunk **180** between the anchor MSC **160** and the target MSC **170**.

The target MSC **170** will then seize resources to be assigned to the arriving mobile station **120**. One of the resources required corresponds to the voice trunk **190**, which carries speech from the anchor MSC **160** to the target MSC **170**. The voice trunk **190** is necessary to continue the conversation between the mobile station **120** (now served by the target MSC **170**) and the mobile station **110** (served by the anchor MSC **160**).

The on-going conversation continues after the mobile station **120** has been handed off to the target MSC **170**. Thus, the on-going call requires four signal interfaces:

the first is the air interface **115** between the mobile station **110** and the anchor MSC **160**; the second is the air interface **117** between the mobile station **120** and the target MSC **170**; the third is the signaling trunk **180**; and the fourth is the voice trunk **190.** Therefore, a successful inter-exchange handoff requires air interface resources for a first subscriber, air interface resources for a second subscriber, a signaling trunk to carry control signaling between the anchor and target MSCs, and a voice trunk to support the call connection between the MSCs. If any of these resources is not available, especially the voice trunk connection **190**, then the call cannot be handed off to the target MSC **170**. Further, it is quite expensive to dedicate voice trunks between MSCs during network definition in anticipation of unknown call volumes.

Turning to Fig. 2, another illustration of interactions between network entities which accentuate the problem of voice communication over trunks in a network can be seen. Initially, the call connection between the telephone **310** and the cellular subscriber **350** includes a VoIP connection **370** between the telephone **310** and the Internet **320**, a VoIP connection **380** between the Internet **320** and the anchor MSC **330**, and a voice over air interface **390** from the mobile telephone **350** to the anchor MSC **330**. Thus, the initial connection between the telephone **310** and the anchor MSC **330** involves two VoIP connections **370**, **380**

At some point, the mobile telephone **350** will move out of the service area for the anchor MSC **330**, and into the service area for the target MSC **340**. At this time, the anchor MSC **330** will determine that a handoff forward operation should occur, in step **400**. First, a HANDOFFMEASUREMENTREQUEST **410** is made from the anchor MSC **330** to the target MSC **340** in step **410**. A handoffmeasurementrequest response is

returned from the target MSC **340** to the anchor MSC **330** in step **420**. Then, a FACILITIESDIRECTIVE to secure the resources necessary for a call connection between the anchor MSC **330** and the target MSC **340** is sent in step **430**. Such resources as a dedicated voice trunk **360** are then seized for use in the call connection to be established between the MSCs **330**, **340**. These resources are provided in step **440**, and a facilitiesdirective response is returned from the target MSC **340** to the anchor MSC **330** in step **450**. A handoff order to the mobile telephone **350** is sent from the anchor MSC **330** in step **460**, and the mobile telephone **350** arrives on the voice channel in step **470**. The target MSC **340** then completes the voice call path connection between the mobile telephone **350** and the trunk in step **480**, and establishes the voice over air interface with the mobile telephone **350** in step **490**. An MSONCHANNEL message is then sent from the target MSC **340** to the anchor MSC **330** in step **500**. At this point, the anchor MSC **330** completes the voice call path connection between the anchor MSC **330** and the target MSC **340** in step **510**, and establishes the voice trunk connection **520**. VoIP connections **370**, **380** now exist between the telephone **310** and the anchor MSC **330**. In addition, a voice over air interface **490** exists between the mobile telephone **350** and the target MSC **340**, and the voice over trunk connection **520** has been established. However, if a dedicated voice trunk **360** is not available to be seized as a resource by the target MSC **340**, the call connection cannot be established between the mobile telephone **350** and the telephone **310**, and the call will be dropped. As the number of MSCs increases (e.g., as the mobile telephone **350** roams out of the service areas of the MSCs **330**, **340**), the scenario gets more complicated, such that other voice trunks and network resources (e.g.,

timers) must be dedicated to serving the mobile subscriber operating the mobile telephone **350**.

Therefore, what is needed, is a method and apparatus using available protocols to obviate the need for voice trunks used to carry speech communication between network subscribers after a handoff operation occurs. Further, such a method and apparatus should provide a way to communicate between network subscribers which does not require tandem MSCs when a call is handed off by way of multiple MSCs. The method and apparatus should be able to make use of commonly available protocols, and should be useful in any type of wireless telecommunication network such as ANSI, Global System Mobile (GSM), and Personal Digital Cellular (PDC) networks.

SUMMARY OF THE INVENTION

The invention provides a method and apparatus for utilizing Voice over Internet Protocol (VoIP) operations to substitute for the allocation of voice trunks in a conventional telecommunications network during intersystem handoff operations. In the network reference model of the invention, Mobile Switching Centers (MSCs) are connected to the Internet via VoIP gateways and Internet access servers. Such Internet connections enable sending voice and signaling messages using VoIP operations. Thus, the apparatus may include a pair of VoIP gateways in electronic communication with mobile switching centers (typically using Internet access services), or a pair of mobile switching centers in electronic communication with corresponding VoIP gateways and an Internet Protocol network.

The apparatus of the invention thus includes anchor and serving MSCs connected to the Internet using VoIP gateways and Internet access servers. Target MSCs may also be included, connected to the Internet using a VoIP gateway/Internet access server combination so that handoff forward call connection operations can be conducted using VoIP.

The method of the invention typically includes determination that a handoff forward call connection operation should occur. Next, the method requires verification that a designated channel of the Target MSC is available to support the mobile station being handed off, as well as the allocation of a second VoIP gateway to the Target MSC. Finally, the voice path is completed by establishing voice pathways between the VoIP gateways and the MSCs. Normally, formatting and recovery of the voice audio signals will occur within the VoIP gateways as the signals are sent and received respectively, from the MSCs.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the structure and operation of the present invention may be had by reference to the following detailed description when taken in conjunction with the accompanying drawings, wherein:

FIG. 1, previously described, is a prior art block diagram illustrating handoff forward methodology;

FIG. 2, previously described, is a prior art network signal flow diagram illustrating handoff forward operations using voice trunks;

FIG. 3 is a network block diagram illustrating the apparatus of the present invention;

FIG. 4 is a network signal flow diagram illustrating the method of the present invention for inter-exchange handoff operations; and

FIG. 5 is a network signal flow diagram illustrating the method of the present invention using handoff-to-third with path minimization operations.

DETAILED DESCRIPTION OF PRESENTLY PREFERRED EXEMPLARY EMBODIMENTS

The invention provides the advantage of using VoIP technology as part of a method and apparatus to perform inter-exchange call handoff operations. Turning now to Fig. 3, a proposed network model wherein the invention is embodied can be seen. In essence, signaling trunks and voice trunks between Mobile Switching Centers (MSCs) are replaced by a network (e.g., the Internet), the VoIP protocol, and various gateways and servers. The resulting network **530** supports handoff forward, handoff back, handoff to third, handoff with tandem, and handoff with path minimization operations.

At the center of the reference network **530** lies the Internet **600**. Access to the Internet **600** is provided using VoIP gateways **580, 620** and Internet access servers **590, 610**. Thus, an Anchor MSC **540** can communicate with the Internet **600** using VoIP by way of the VoIP gateway **580** and the Internet access server **590** (which may be separate physical units, or integrated into a single physical unit). Similarly, the serving MSC **630** can communicate with the Internet **600** using VoIP by way of the VoIP gateway **620** and the Internet access server **610** (which may also be separate units, or

integrated into a single unit). Typically, two VoIP gateways **580**, **620** are required to eliminate the need for a voice trunk. Telephone service subscribers may communicate, for example, with the anchor MSC **540** using the Public Land Mobile Network (PLMN) **550**, the Public Switching Telephone Network (PSTN) **560**, or an Integrated Services Digital Network (ISDN) **570.** Typically, a mobile telephone **660** subscriber will make use of an air interface **670** to communicate with a base station **650** and a Serving MSC **630** as its entry point into the network **530**. As noted in Fig. 3, the signaling link between the MSCs **540**, **630** can be supported by using the Signaling System 7 (SS7/C7) signaling trunks **640**, or the Internet **600**. Of course, signaling using the signaling trunks **640** and the SS7 protocol are well known to those skilled in the art.

Fig. 4 illustrates a network signaling flow diagram demonstrating the method and apparatus of the invention implementing a handoff forward operation. When the final voice connection is established, it includes a VoIP interface (between the PSTN subscriber, not shown, and the Anchor MSC **540**), a VoIP interface (between the anchor MSC **540** and the new Serving MSC **630**), and a voice over air interface (between the new Serving MSC **630** and the Mobile Station (MS) **660**. The signaling messages between the MSCs can be sent using conventional signaling trunks, or over the Internet.

In Fig. 4, the network elements, including the Internet **600**, the access servers **590**, **610**, the gateways **580**, **620**, and the MSCs **540**, **630**, are identical or similar to those described in Fig. 3. Similarly, the MS **660** corresponds to the telephone **660** in Fig. 3.

Initially, there is a conventional call connection **1000** between the originating PSTN subscriber (not shown) and the Anchor/Serving MSC **540**, wherein the

voice information is sent to the MS served by the anchor MSC **540** using an air interface **1010**. At some point, as the MS **660** moves away from the MSC **540**, the MSC **540** determines that a handoff to an adjacent candidate MSC is appropriate. This occurs in step **1020**. A HANDOFFMEASUREMENTREQUEST message **1030** is sent from the anchor MSC **540** to the potential Target MSC **630**. A handoffmeasurementrequest response **1040** is returned from the Target MSC **630** to the Anchor MSC **540**, which results in verifying that the MSC **630** will be the Target MSC **630** for the handoff operation.

The Anchor MSC **540** then allocates the first VoIP gateway **580** in step **1050** to prepare for VoIP communication from the Anchor MSC **540** to the Target MSC **630**. The Anchor MSC **540** then sends a FACILITIESDIRECTIVE Invoke message **1060** to the Target MSC **630**, which directs the Target MSC **630** to initiate a handoff forward task. In step **1070**, after receipt of the FACILITIESDIRECTIVE message, the Target MSC **630** allocates the second VoIP gateway **620** and assigns a voice channel. The Target MSC **630** sends the facilitiesdirective response **1080** to the Anchor MSC **540**, including an indication that a voice channel is available, and the Internet Protocol (IP) address information for the second VoIP gateway **620**. The Anchor MSC **540** then stores the IP address of the second VoIP gateway **620** in step **1090**.

At this point, a Mobile Handoff Order **1100** is sent to the MS **660**, to indicate that the MS **660** should be attached to the newly-assigned voice channel of the target MSC **630**. The MS **660** then arrives on the designated voice channel of the Target MSC **630** in step **1110**. The Target MSC **630** then completes the voice call path between the MS **660** voice channel and the second VoIP gateway **620** in step **1120**. At this time,

the Target MSC **630** completes the voice call path connection between the MS **660** voice channel in the second VoIP gateway **620** in step **1130**, establishes the voice over air interface with the MS **660** in step **1140**, and sends a MOBILESTATIONONCHANNEL message **1150** to the Anchor MSC **540**. It should be noted that using the VoIP gateways **580**, **620** obviates the need for conventional inter-MSC voice trunks.

After receiving the MOBILESTATIONONCHANNEL message **1150**, the Anchor/Serving MSC **540** completes the voice call path **1170** between the call connection and the first VoIP gateway **580** in step **1160**. The Anchor/Serving MSC **540** also sends a request to the first Internet access server **590**, including the IP address of the second VoIP gateway **620** so that voice data, using VoIP, can be sent to the Target MSC **630**. This also occurs in step **1160**. Thus, the Anchor/Serving MSC **540** is simply known as the Anchor MSC **540**.

At this point, the VoIP link between the Anchor MSC **540** and the MS **660**, is complete. The VoIP link includes the VoIP call connections **1130**, **1170;**, the network connections **1190** and **1210** between the first and second VoIP gateways **580**, **620** and the first and second Internet access servers **590**, **610**, respectively; and the network IP connections **1200** between the Internet access servers **590** and **610**. Communication occurs by sending voice audio from the Anchor MSC **540** to the first VoIP gateway **580**, converting or formatting the voice audio into a format suitable for transmission over the network to the second Internet access server **610** using the first Internet access server **590** (i.e., VoIP formatted voice), receiving the formatted voice audio at the second Internet access server **610,** and recovering the original voice audio at the second VoIP gateway **620** (i.e., converting the VoIP formatted voice-to-voice audio),

receiving the recovered audio at the Serving MSC **630**, and sending the voice audio from the Serving MSC **630** to the MS **660** using the assigned voice channel. Using VoIP to send voice from one VoIP gateway **580** to another VoIP gateway **620** are well known to those skilled in the art, as described in the document "Voice over IP (VoIP)" sponsored by Technology Networks as part of its Technology Guide Series, herein incorporated by reference in its entirety (*See* VOICE OVER IP (VoIP) (Jerry Ryan ed., The Applied Technologies Group, Inc. 1998)). A series of similar steps are performed by the new Serving MSC **630**, working backward through the chain of the second VoIP gateway **620**, the second Internet access server **610**, the Internet **600**, the first Internet access server **590**, the first VoIP gateway **580**, and the Anchor MSC **540** to send voice audio from the MS **660** to the Anchor MSC **540**, and on through the call connection **1000** to the originating subscriber.

Turning now to Fig. 5, the apparatus and method of the invention used to implement a handoff-to-third with path minimization operation (no Tandem MSC is needed) can be seen. When the final voice connection is established, it includes VoIP interfaces **1450**, **1370**; the network connections **1190**, **1470**; and the VoIP network connections **1200**, **1460**; along with the voice over air interface **1360** between the MS **660** and the Target MSC **636**. As noted above, signaling messages between the MSCs **540**, **630**, and **636** can be sent over conventional signaling trunks, or over the Internet **600**. Again, the illustrated network elements correspond to those described in Fig. 4, with the addition of a third VoIP gateway **634** operating through a third Internet access server **632**, and an additional MSC **636**, to which the MS **660** is handed off from the

Serving MSC **630**. Initially, the link between the Serving MSC **630** and the Anchor MSC **540** is established as described for the network of Fig. 4.

As the MS **660** moves out of the service area of the serving MSC **630**, the serving MSC **630** determines that a handoff to an adjacent candidate **MSC** is needed (in this case, the potential Target MSC **636**) in step **1220**. The Serving MSC **630** then sends a HANDOFFMEASUREMENTREQUEST message **1230** from the Serving MSC **630** to the candidate Target MSC **636**. After receiving the handoffmeasurementrequest response **1240**, the Serving MSC **630** determines that the call should indeed be handed off to the candidate Target MSC **636**, and that path minimization may be possible. This determination is made in step **1250**. A HANDOFFTOTHIRD Invoke message **1260** is then sent from the Serving MSC **630** to the Anchor MSC **540**, requesting the Anchor MSC **540** to perform a handoff with path minimization.

At this time, the Anchor MSC **540** prepares to establish a VoIP call connection **1450** by allocating the first VoIP gateway **580** in step **1270** to redirect the call connection to the new MSC (**636**). The Anchor MSC then sends a FACILITIESDIRECTIVE Invoke message **1280** to the Target MSC **636** to initiate allocation of resources. After receipt of the FACILITIESDIRECTIVE message **1280**, the Target MSC **636** allocates the third VoIP gateway **634** and assigns a voice channel for use by the MS **660** in step **1290**. The Target MSC **636** then sends a facilitiesdirective response **1300** to the Anchor MSC **540**, including an indication that a voice channel has been assigned, and the IP address information for the third VoIP gateway **634**. Upon receipt of the facilitiesdirective response **1300**, the Anchor MSC **540** stores the third

VoIP gateway **634** IP address in step **1310** and sends a handofftothird response **1320** to the Serving MSC **630**.

After receiving the handofftothird response **1320**, the Serving MSC **630** sends a Mobile Handoff Order **1330** to the MS **660**, which indicates that the MS **660** should attach itself to the newly-assigned voice channel on the Target MSC **636**. The handoff order is given in step **1330**, and the MS **660** arrives on the assigned voice channel in step **1340**.

The Target MSC **636** then completes the voice call connection **1370** between the voice channel and the third VoIP gateway **634** in step **1350**, establishes the voice over air interface with the MS **660** in step **1360**, and sends a MOBILESTATIONONCHANNEL message **1380** to the Anchor MSC **540** (i.e., the initiator of the handofftothird task). At this time, the Target MSC **636** is designated as the new Serving MSC **636** in step **1390**.

Upon receipt of the MOBILESTATIONONCHANNEL message, the Anchor MSC **540** sends a FACILITIESRELEASE message **1400** to the (old) Serving MSC **630** so that the second VoIP gateway **620** and second Internet access server **610** can be released, along with the VoIP connection **1130**, which is no longer needed. In step **1410**, the VoIP connection **1130** is released, along with the second VoIP gateway **620**, the second Internet access server **610**, and the (old) Serving MSC **630**. The Serving MSC **630** marks the second VoIP gateway **620** as idle in step **1420** and returns a facilitiesrelease response **1430** to the Anchor MSC **540**.

Upon receipt of the facilitiesrelease response **1430**, the Anchor MSC **540** completes the voice call path connection **1450** between the voice trunk and the first VoIP

gateway **580** in step **1440**. The Anchor MSC **540** also sends a request to the first Internet access server **590**, via the first VoIP gateway **580** (including the IP address of the third VoIP gateway **634**), to enable VoIP operations from the Target MSC **636**. At this point, the VoIP link between the Anchor MSC **540** and the Target MSC **636** is complete. The link includes the VoIP call connections **1450**, **1370**; the network connections **1190**, **1470**; and the VoIP Internet connections **1200**, **1460**. Of course, the call connection **1000** and the voice over air interface **1360** are used to complete communications between the MS **660** and the originating subscriber (not shown). As with the scenario illustrated in Fig. 4, the communication connection between the MS **660** and the originating subscriber does not need to use any voice trunks, and may also eliminate the use of signaling trunks. In the network operations illustrated by Fig. 5, only the first and third VoIP gateways **580**, **634** and the first and third Internet access servers **590**, **632** are required for voice communication between the Anchor MSC **540** and the Target MSC **636**.

Although the invention has been described with reference to specific embodiments, this description is not meant to be construed in a limited sense. The various modifications of the disclosed embodiments, as well as alternative embodiments of the invention, will become apparent to persons skilled in the art upon reference to the description of the invention. It is, therefore, contemplated that the appended claims will cover such modifications that fall within the scope of the invention, or their equivalents.